(2)

1992
Executive Research Project
A208

Earth Observation From Space: Competition or Cooperation?

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Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY N/A	3. DISTRIBUTION / AVAILABILITY OF REPORT Distribution Statement A: Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NDU-ICAF-92- 4208	5. MONITORING ORGANIZATION REPORT NUMBER(S) Same
6a. NAME OF PERFORMING ORGANIZATION Industrial College of the Armed Forces 6b. OFFICE SYMBOL (If applicable) ICAF-FAP	7a. NAME OF MONITORING ORGANIZATION National Defense University
6c. ADDRESS (City, State, and ZIP Code) Fort Lesley J. McNair Washington, D.C. 20319-6000	7b. ADDRESS (City, State, and ZIP Code) Fort Lesley J. McNair Washington, D.C. 20319-6000
8a. NAME OF FUNDING / SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Earth Observation from Space: Competition or Cooperation?

12. PERSONAL AUTHOR(S)

David Oberthaler

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Research	FROM Aug 91 TO Apr 92	April 92	37

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

SEE ATTACHED

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Judy Clark	22b. TELEPHONE (Include Area Code) (202) 475-1889 22c. OFFICE SYMBOL ICAF-FAP

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

ABSTRACT

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An examination of the issues surrounding future policy decisions pertaining to the application of national space resources in remote sensing. The main focus of this unclassified paper is on the proper balance between cooperation and competition in future remote sensing activities as it applies to unclassified sensing systems. Conclusions include recommendations for specific areas for cooperation and competition.

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INTRODUCTION

The United States, as the world's foremost pioneer in the exploration and development of space, is facing some important decisions in applying its space resources to secure its future as a world leader. It will move forward into a world with new and developing technologies and, at the same time, will face the challenge of protecting its national interests in a world undergoing significant political, military, economic, and social changes. In the words of author and economist Dr. William Woodruff (1):

> "One thing is certain, we have reached a most paradoxical stage of world history. While science, technology, economics, ecology, health care and a host of other forces are drawing the world together (these forces demand a global order), intangible forces such as religion, race, and nationalism are beginning to break the world apart."

The purpose of this paper is to examine how the United States should balance its international cooperation and competition as it pertains to earth observations or remote sensing from space (2). Earth observations or remote sensing includes all forms of observation by sensors borne by a space object including visual, optical or any form of radiometrically produced images and any measurements taken of the earth's surface, its atmosphere or its weather systems (3). The capabilities of remote sensing are as varied as the sensors that are built and put in orbit, but

capabilities fall into two general categories; imagery and measurement.

Imagery includes visible light photography, infrared photography, and radar images of the earth's surface. Imagery also has the broadest application cutting across scientific, economic and national security lines. Accurate and detailed images of the earth's surface can be produced through cameras, radars, and specialized scanners to improve the accuracy of maps, observe and assist in weather reporting and prediction, assess the impact of man on his environment, and assess the status of crops and natural resources.

Measurement accomplished using remote sensing has largely scientific applications including the production of data on the chemical composition of the earth's atmosphere, measurement of radiation, and precise measurement of landmass position and movement. This data contributes to the study of the earth, its environment, and can be used as a predictor of future change.

In addition to peaceful imagery and measurement applications, remote sensing also has implications for defense. The information yielded by remote sensing helps shape a nation's security decisions through evaluating one's own economic or geographic assets or that of an adversary or ally. For example, the ability of one nation to observe and study another through space-borne sensors permits strategic assessment of a potential adversary's or ally's natural resources and crops contributes to evaluating those nations' abilities to sustain their populations and their armed forces. In addition, more precise geographic knowledge of a country may be obtained to update maps and speed navigation and ') evaluate population distribution, ports, and other large

manmade features.

Why should we be concerned with the idea of formulating a policy addressing the question of competition or cooperation for such observations?

The first and most important reason is preservation of national power. Political scientist and author Hans Morgenthau (5) has presented a clear concept of a nation's power. In its most basic form, power is the ability of one nation to influence the actions of other nations. Morgenthau (6) describes nine elements of national power of which the following three are most important in the discussion of the application of earth observation technology:

- Geography as it pertains to natural resources
- Industrial capacity and its relation to technology
- Military preparedness and technology

Natural resources are important components of the strategic power of the United States. The U.S. must be able to accurately assess its own resources and to look beyond its boundaries for the materials to fuel its economy. Today, earth observation from space gives us unique tools to explore our country as well as the rest of the world.

In addition to maintaining its strategic power, the United States must also be concerned with the environment as a relevant issue for its future. In hearings before Congress in July of 1990 (7), the prevalent theme voiced by Congressmen and business leaders was the use of satellites as

part of a worldwide system to observe, protect and improve the global environment through observation and study. Economist Henry J Aaron (8) writing for the Brookings Institution argues that the future is not certain in regards to the effects of global warming and its impact on the economies of the world. The fact that the environment is a matter for study and national policy discussions is a signal of its potential importance for our future. The global environment is being recognized as a "resource" for the United States and the world. This recognition is bringing about change in the international community.

The nations of the world are slowly realizing that they are members of a world community. Countries are seeing that actions taken by them in a variety of areas have effects outside their national boundaries. For the United States, an excellent example is the "export" of acid rain to Canada which has now led to agreements between the U.S. and Canada aimed at reducing those compounds contributing to the problem. In the spring of 1986, the former Soviet Union was able to threaten its own health as well as the health of many of its European neighbors as a result of the world's most serious nuclear accident at Chernobyl (9). The countries of South America increase the threat of global warming with massive destruction of rain forests, but now are being influenced to reduce this destruction by data gathered from satellite-borne sensors.

The United States, with its industrial and technical capacity to support remote sensing, is in an excellent position to influence its future and to make important contributions to the world community. The U.S. has already made a significant contribution to world stability with the application of remote sensing in the 1991 Gulf War (10). The satellite

technology applied there included remote sensing platforms in their more traditional role as well as global positioning and intelligence gathering platforms. The space technological and industrial base made a significant contribution in military capability but, moreover, provided a timely boost to the nation's power and prestige. The linkage between military preparedness and technology is a key component of U.S. national power.

The second reason for the formulation of a remote sensing policy is the political and technical leadership roles that have been assumed by the United States in the world community. The U.S. can contribute to world order and, at the same time, maintain its international standing in space activities. If it can be accepted that the actions of the United Nations are a fair representation of the world view, then the U.S. must recognize that the world has a definite opinion on the importance of remote sensing and its implications for the future. While recognizing that governments will use such technology to their own advantage, the United Nations incorporated the following "world views" in General Assembly Resolution 41/65 (4) dealing with the issue of remote sensing:

- Principle X: "Remote sensing shall promote the protection of the Earth's natural environment..."

- Principle XI: "Remote sensing shall promote the protection of mankind from natural disasters..."

- Principle XIII: "To promote and intensify international cooperation, especially with regard to the needs of developing countries..."

Remote sensing is an important capability for the United States and other members of the world community. It enables accurate assessment of natural resources, it has the potential to assist in protection of the earth's environment, and it can contribute to national and international security. Remote sensing is a young science which began its development in the early years of the U.S. space program.

HISTORY

Earth observation has been a key component of national strategy since 1958 when President Eisenhower approved NSC 5814/1/, "Preliminary U.S. Policy in Outer Space" (11). Our efforts to gather information about the earth begin in earnest in April of 1960 with the launch of TIROS (Television and Infrared Observation Satellite) which observed weather patterns in the United States and the tropics (12). This was soon followed by the successful launch of Discoverer 13 on August 10, 1960 (13) with the purpose of gathering remotely sensed intelligence information. Today, the family of earth sensing satellites has grown dramatically both in number and function.

In the early days satellites were oracles invisibly measuring, by their optics, the size and shape of our adversaries and in so doing helping to shape U.S. strategy. Work with early reconnaissance satellites generated an interest for earth observation by scientists in the early 1960's (14). This interest, born out of a relationship between scientists and the

defense establishment, had an impact on sensor development and policy and continues to influence the future of earth observation for peaceful purposes.

Spurred by the growth of scientific interest, NASA developed the Earth Resources Technology Satellite (ERTS) project beginning in 1964. The first satellite launched under this system in 1972, was ERTS-1 (15). ERTS satellites were renamed Land Remote-Sensing Satellites (LANDSAT), a name which remains in use today with LANDSAT 4 and 5 in orbit and a plan for the launching of LANDSAT 6. These satellites were originally experimental, imagery producing platforms administered by the National Oceanic and Atmospheric Administration (NOAA). LANDSAT data became a candidate for entry into the commercial sector where there appeared to be an imagery market. Responsibility for system operations was later transferred from NOAA to a private firm, Earth Observation Satellite Company (EOSAT). This system of earth sensing satellites continues to function today.

CURRENT POLICY

Current U.S. space policy, setting the direction of the nation's space program, was announced in November of 1989 (16). A primary policy goal, perhaps the most important one from a national strategy standpoint, is the maintenance of U.S. leadership in space activities. The policy also sets forth the following six supporting objectives for our space program:

1. Strengthen security of the U.S.

2. Obtain scientific, technological, and economic benefits for the general population and to improve the quality of life on earth through space related activities.

3. Encourage continuing United States private-sector investment in space and related activities.

4. To promote international cooperative activities taking into account United States national security, foreign policy, scientific, and economic interests.

5. To cooperate with other nations in maintaining the freedom of space for all activities that enhance the security and welfare of mankind.

6. To expand human presence beyond Earth orbit into the solar system.

A comparison of U.S. policy with that enunciated in United Nations Resolution 41/65 (17) shows little substantive difference save one key point; U.S. concern for our role as the world leader of space resourced nations.

The U.S. space policy of 1989 reflects a continuation of previous policy. The space program goals announced by the White House in 1989 are the same as those identified in 1988 as part of the "Presidential Directive on National Space Policy" (18). Another example of previously published policy was the "State Department White Paper on New

International Satellite Systems" (19) submitted during Congressional hearings in April, 1985. Although the paper mainly focused on communications satellites, it contained the following more general goals which portrayed our nation's general philosophy in the area of satellite technology:

- To enhance the free flow of information and ideas among nations.
- To ensure the continued technological and economic strength and leadership of the United States in the communications, information and aerospace fields.
- To promote extended international trade and to ensure opportunities to U.S. firms to participate in such trade.
- To ensure the needs of national defense, security, and emergency preparedness are satisfactorily met.

The United States has remained committed to its major goal of retaining its leadership in space and this leadership is based in a large part on commerce and the supporting space industry.

COMMERCE AND SPACE INDUSTRY

Commerce and space are strongly linked to one another. Assistant Secretary of the Air Force for Space, Martin Faga, has even said, "...

virtually all U.S. space activities are in some sense commercial activities."(20). This would also apply to scientific as well as defense endeavors as industry provides much of the development and production capabilities to support the programs. Most space and space related activities are commercially related whether through direct sale of a product or service or by virtue of a commercial application.

The financial stakes associated with earth sensing technology are high. According to a 1985 forecast by the Center for Space Policy, "gross revenues for remote sensing could reach $2 billion annually by the year 2000" (21). Author Joan Johnson-Freese recognizes that this figure may be an overestimate, however, no analysts in this field deny the probability of strong growth in the field although the magnitude is the subject of some conjecture. Another space policy analyst, J. Brantley Lightfoot, (22) proposes "economic C3 (command, control, and communications)" to help redefine our space economics and asserts that communications is our only money maker other than satellite manufacture and launch. The main thrust of his arguments for an economic space policy with a strong and practical appeal is a single premise - space business is big business.

To provide some understanding of the magnitude of the business, Lightfoot cited a study based on NASA's $11.3 billion budget for 1990. The study "...found that NASA's budget provided $23.2 billion in corporate profits, $74 billion in local, state, and federal taxes; and employed 237,000 people". The implications of space business seem clear. It is already making a substantial economic contribution to the nation with the potential grow much larger.

Although earth sensing data potentially is a large source of revenue

for the U.S. economy, it has not been fully developed. The slow emergence of remote sensing as a commercial enterprise has been attributed to two factors; 1) poor market development by the government and, 2) cautiousness on the part of potential customers to rely on a program that has an erratic pattern of funding support. What customer would rely on a system threatened by shutdown for lack of government funding? Just such a scenario developed in 1989 (23) when NOAA, then responsible for LANDSAT operations, ran out of money for continued operations of the LANDSAT system. Eleventh hour intervention by the National Space Council under the leadership of Vice-President Quayle provided the necessary funds and prevented an interruption of service.

The primary benefits derived from the commercial sector are income and markets. Increases in income for the space industry provide potential for profit and capital investment while providing more tax revenue for federal and local governments. Success in commercial enterprise also means a change in markets. The more commercial applications that can be found and exploited, the greater the income and the greater the potential for more markets. In a less direct fashion, commercial applications could develop new customer-oriented operational requirements calling for further product development or refinements that could have applications in science or defense. Although the history of earth-sensing satellites demonstrates the roots of scientific interest in the defense intelligence systems (24), it is possible that future developments with defense applications could be born from the need for new or improved commercial equipment.

All remote sensing is supported by industry. Industry translates the

needs or specifications for remote sensing activities into working sensors, platforms, and systems then provides the means for launching and support. This applies to all applications; commercial, scientific, or defense.

There are no substitutes for this industry which has been a key component of the U.S. space program since its birth in the '50s. Robert Anderson of Rockwell International sees promise in the future of the industry in that it has room to grow. Anderson asserted that space is "the next industrial frontier" and laid out a three step process for developing space to "its fullest potential" in his presentation to the 2nd International Conference on the Commercial and Industrial Uses of Outer Space in Montreaux, Switzerland in 1988 (25). Anderson also recognized a key limitation that affects both the U.S. and other space resourced states - the U.S. cannot do it all.

All nations, including the U.S., will have to rely on cooperation as well as competition in order to derive the most benefit from space and its industries. The choice is how to choose the balance between competition and cooperation.

How should the balance be struck? We need to look first to one of the most critical national interests of the U.S.

DEFENSE

The use of earth-sensing satellites in defense contributes directly to;

1) the protection of national security and the nation's interests while, 2) yielding potential contributions in research and development with scientific or commercial applications.

The ability to defend the nation and to be a leader in the application of technology contribute to the national power of the United States. Remote sensing will contribute to the defense of the nation by providing a means for strategic assessment of national resources and the resources of adversaries and allies. In addition to such assessments, remote sensing enhances the prestige of the U.S. as a leader in a highly technical field.

Cooperation in earth observations from space will yield the diffusion of data and proliferation of technologies to countries whose interests and policies are in opposition to those of the U.S. The transfer of information and technology to competitors or enemies will occur through activities such as international science forums where scientists discuss solutions to remote sensing problems they have already overcome and proposals for solutions to unresolved problems.

The availability of shared scientific data as well as commercially available data from remote sensors could provide a nation important strategic information without that nation ever investing its own money in a satellite system. Further, the availability of certain data such as soil type or crop identification can suggest the nature of the technology in use. For example, a country studying U.S. technology could conclude that an infrared sensor was in use thereby suggesting a system or technique for future use by a country which may not agree with U.S. policy or actions.

How should we view the knowledge produced by the advancement and

distribution of data and sensing technology from the standpoint of national security?

To begin with, the U.S. cannot expect to control satellite technology and its ultimate direction. Our "best case" is to be able to influence the development and transfer of such technology. At one time, this country and the former Soviet Union were the only "space resource states" in the world. That is to say that they were the only states with the technological and industrial capacity to design, launch and receive and process information from satellites. We controlled the gathering as well as the dissemination of earth-sensed information simply because we possessed all the technology.

We are no longer in the position of possessing a technological monopoly. Countries such as France with its SPOT (Systeme Probatoire d'Observation de la Terre) system are routinely producing commercial imagery for sale to any buyer (26). Our own Department of Defense has been a SPOT customer, purchasing imagery in support of the Gulf War to compliment imagery purchased from EOSAT and produced by LANDSAT 4 and 5 (27). Other countries such as Japan and its MOS (Marine Observation System) are also capable of state of the art earth observations. The door to extensive geographical and agricultural data has been opened with many additional countries receiving satellite data without having to invest in satellite systems of their own. As of 1985, over 1000 receiving stations in 120 countries were routinely receiving such data (28).

What are the security implications of this free flow of commercial imagery and other satellite-sensed information? Authors Levy and

Chodakewitz (29) forecasted possible uses of satellite imagery in cross-border conflicts. Their hypothesis was "... commercial imagery will play an increasingly significant role in Third World cross-border conflicts". Levy and Chodakewitz conclude that commercial systems can produce "dual-use" data; data having both peaceful and military purposes. According to their work, a Third World subscriber to commercial, remotely sensed data could use the information to draw conclusions and make decisions based on their own strengths or weaknesses and the strengths and weaknesses of an adversary. Such a nation could use information such as poor crop production to forecast civil unrest among the population of a neighboring enemy country and conclude that the timing was right for an invasion. Their use of remotely sensed data could influence future U.S. decisions and policy in their region.

A possible Third World scenario with implications for U.S. interests could be played out in Southwest Asia. Iran could subscribe to commercial imagery to plan invasion routes into a weakened Iraq and locate and evaluate U.S. forces in the area, then execute the invasion with the resulting instability threatening U.S. access to the region's oil. The U.S. may feel it necessary to consider action either under the auspices of the United Nations or unilateral action. Commercial imagery also could play a positive, conflict resolution role in the same hypothetical situation between Iran and Iraq. Imagery could indicate inadequate invasion routes or the presence of large Iraqi units causing Iran to postpone or to avoid the conflict altogether. In both cases, the U.S. could be influenced in its decisions regarding diplomatic, military, and economic actions protecting its interests in an area of vital interest.

If we accept that the U.S will be focusing its efforts on a regional basis, any technical system that either could trigger or prevent a regional conflict would be of interest. Therefore, U.S. policymakers should maintain a keen interest in developing policy to control sensing technology.

COMPETITION

As far as space commerce is concerned, the estimated $2 billion dollar potential for the remote sensing market constitutes a significant economic interest for U.S. policymakers and business leaders. The United States has been in competition in space related activities since the 1950's. Competition then was very straightforward. Our only competition was the former Soviet Union who provided a "wake-up call" for our nation when they successfully launched the world's first artificial satellite in 1957. The name of that satellite, Sputnik, still recalls for some Americans a certain sense of defeat. Considering the strategic view, the Soviets did us a favor by providing a reminder that we could be bested by a country we probably held as technologically inferior.

The question now is whether or not the U.S. will be bested again. From our restated Space Policy of 1989, it is clear we want to be number one in space and our national leadership is pushing us towards that goal. Our competitors are now many compared to the few of the simpler days of the '50s. Johnson-Freese (30) identifies our new competitors as Germany, France, India, Japan, Brazil, China and the Soviet Union (Commonwealth of Independent States or CIS). A survey of the literature

suggests that our three top competitors are France, Japan and Germany.

The CIS does not rank as a top competitor for good reason. In spite of all of its tremendous potential, the future role of the CIS in the exploration of space is not clear. The CIS certainly has the industrial capability and the requisite skills and experience to be a serious competitor, however recent indications suggest that the CIS will not be a competitive space threat for some time. This is due in part to budget considerations and their penchant for highly centralized control. Stephene Chenard (31) reported that the CIS had accomplished only 38 launches within the first eight months of 1991 and Chenard estimated a total of 50 launches for the year. This would mean that the CIS would be launching only a little more than half of what they launched per year in the mid-1980s and would produce "the country's lowest launch rate since 1966 . . .".

The CIS' attitude towards control of remote sensing by their intelligence community has set up obstacles in establishing a civilian remote sensing program. Soyuzkarta, a Soviet civilian remote sensing agency, was repeatedly denied satellite imagery by organizations such as the Chief Intelligence Directorate (GRU) and the Navy Intelligence Directorate. Chenard (32) reported these difficulties but suggests some progress in moving the CIS civilian space program forward. Considering the distractions of current political, economic and ethnic turmoil in the CIS, it would seem highly unlikely that they will be serious contenders for future leadership in space, however the CIS does possess the potential to become a competitor in space activities once again.

Another reminder of our country's position in competitive space

related activities is the emergence of SPOT Image as a commercial challenger in earth observation data. SPOT Image is more aggressive as a commercial enterprise compared to our somewhat similar EOSAT Corporation and its imagery products. This aggressiveness was reflected by Pierre Bescond of SPOT Image when he presented two simple but important ideas (33) during a March 1989 symposium on space commercialization that point to SPOT's understanding and philosophy of commercial competition in earth observation. These ideas are:

- develop advanced technology to meet the needs of the user as opposed to an orientation towards research or unimaginative application of existing technology

- pay for the launch of future satellites through the development and establishment of a worldwide commercial data distribution system

These ideas are important because they represent a very practical concept: giving the user what he needs leading to increased revenues and expanded markets. France then is ready to compete and has definite ideas for maintaining and developing the remote sensing market.

COOPERATION

The exploration of outer space and its uses seems to be an area of

human endeavor that truly fosters cooperation. While one might wish to think of such cooperation as an example of altruism, there are some very practical reasons for cooperation.

In the case of the United States, early enthusiasm for cooperation may have been mostly pragmatic. The U.S. encouraged cooperation because support was needed for tracking stations, scientific satellites, manned flight, deep space and astrophysics programs. Little has changed regarding those needs, but today some new considerations have arisen.

As the world has changed and our societal structures have aged, our government faces fiscal challenges more severe than those of the past. Concerns with budget constraints not only demand that more be done with less but also cause more concern with risk and methods to distribute both costs and risks. International cooperation in earth observation can help alleviate some of the financial burden and also can help by dividing up risks associated with system construction, launch, and operation. But these, once again, may be the most practical of concerns.

Cooperation also can yield some less tangible benefits such as the intellectual contributions of international scientists to sensing projects sponsored by or participated in by the U.S. The U.S. has an excellent opportunity to derive such benefits as it embarks on its Mission To Planet Earth (MTPE). MTPE is a large and complex international program focused on the study of earth sciences. In particular, the program will collect, analyze, and archive data about the earth's environment. This program will make extensive use of international talent, technology and cooperation as it combines the resources of our nation, Europe, and Japan (35).

The issue of the earth's environment appears to have the greatest potential in driving the U.S. and other space resource nations toward cooperation on remote sensing. In the long run, it is a matter of quality of life and the health of the world's inhabitants. In the shorter run, it could well be a matter of economics if changes to the environment begin to decrease food supplies or influence industrialized countries in production through limiting access to natural resources. The concept of coordinating the development and use of international resources for a common good such as the study of the earth's environment offers a brighter picture of our future.

An undertaking as complex as Mission To Planet Earth is not without precedent. When the opportunity to observe and study Halley's Comet in 1986 riveted the imagination of scientists, the United States joined an international group assembled for that single and special purpose. The U.S. was not necessarily attracted to this undertaking by a true spirit of international cooperation without obtaining something in return. As described by Johnson-Freese (36), the U.S. was probably drawn into such a cooperative effort due to political and budgetary considerations. Only one major space resource nation did not send a spacecraft to observe Halley's Comet - that nation was the United States.

This decision on a spacecraft to Halley's Comet may have been a disappointment for our scientific and space community, but it may better be described as a realistic glimpse into the future. It was a case of a realistic appraisal of the U.S. position that the U.S. was not prepared to commit the resources to build, launch and operate a special purpose spacecraft. This is probably one of the best examples of "no one can do it

all" and a solid argument for the expense-sharing benefits of international cooperation in expensive space ventures

Coordination of the international study of Halley's Comet was accomplished by a new organization brought together for this purpose. The organization was known as the Inter-Agency Consultative Group (IACG) (37), and its success in orchestrating international resources may serve well as a model for future cooperative efforts.

CONCLUSION: The Case for Prudent Decisions

There is little doubt that the United States would be in a much stronger position if it maintained its role as the world's leader in space related activities and more specifically in earth observation from space. The nation will continue its efforts in the exploration of space as announced in its national space policy, but must push onward in that endeavor with an eye toward long term goals and achievements. In the words of Congressman Ron Packard as he spoke to his colleagues of the importance of the future of the U.S. space program ('38):

> "As the leader in this international effort, the United States is faced with the challenge of reaching the highest level of national and international coordination to maximize redundancy and share costs, while at the same time protecting the future interests of the United States private sector."

Before determining a future course, the U.S. will need to complete a strategic assessment and determine the direction it will take in sensing policy. The nation will need to determine its interests, goals and objectives and incorporate them into a comprehensive remote sensing policy.

The only criteria that should be applied in determining which space programs should be supported is which programs best support the goals and objectives of the U.S.. Once a program is identified for application of our space resources, the balance of cooperation and competition must be decided then applied.

Within a single project, whether commercial or governmental, we must adjust the mix of competition and cooperation. At a national level, our activities in this area must be adjusted to best fit our nation's needs. This means that in a single project such as Mission To Planet Earth, the U.S. should see both elements of cooperation and competition.

I do, however, believe there are three areas in which we must strongly, perhaps exclusively, devote our nation to competition. These areas are; 1) commercial remote sensing systems, 2) emerging sensing technologies and, 3) defense related sensing technologies. We cannot afford to be timid or apologetic in our pursuit of leadership in these areas.

Commercial remote sensing is a relatively new business and one that has been slow to develop. Our current entry in that enterprise is the LANDSAT system. Although this system cannot pay for itself now, it represents our first attempt at creating saleable products based upon data gathered from outer space. In a more important sense, our experience with

LANDSAT also may serve as a model for future commercial ventures even though it is not profitable now and not expected to become so in the near future. Its utility as a model may be argued since it has never been completely privatized with heavy government subsidies supporting its operations. It is, however, an excellent vehicle for learning about the marketing of remotely sensed data.

Quick returns on investments should not be sought nor should such improvements be measured on their potential commercial value. The goal should be to remain a leader by spirited competition in producing the best or most innovative methods in earth observation through applied research.

As the search continues for new technologies to provide more accurate methods to measure and study the environment and the surface of the earth, innovations will evolve. Many will be incremental improvements in existing technology. These improvements could be similar to the idea of improving resolution for an optics based sensor on a satellite or perhaps discovering a new method of manipulating digitized data to produce new or more accurate products. Improved products could include computer-enhanced images and measurements to determine natural resource distribution such as minerals, water supplies, forests or domestic crops.

The final area offered for competition is that of defense intelligence systems based on earth observing technologies. Some earth observation satellites can serve as dual-purpose platforms fulfilling peacetime as well as wartime roles. Looking to our most recent history we find that we used peacetime remote sensing platforms to help us wage effective warfare in the Gulf. We used at least two "peacetime" systems; LANDSAT and SPOT

to provide up to date imagery to allied forces (39) Some authors have put forth the notion that the Gulf War was the world's first "space war", while most seem to hold to the idea that tne Gulf War was a modern conflict whose results were affected by space technology. In either case, the conclusion that defense related sensing technology should be undertaken in a spirit of competition is supported by recent experience. Ideally, the U.S. should be self sufficient in remote sensing.

Competition, whether based on a desire to be the leader or the desire to be successful in a commercial sense must be considered in a much broader context; the international context. The fact that the U.S. has been the leader in space activities for over thirty years has made a contribution to our national power. The dimensions of this contribution cannot be measured in absolute terms but our nation remains in a position where it can clearly influence the actions of other countries. Success in competition has the potential to bring us two major benefits; power and prestige on an international level and economic development of our space industries. As previously stated, the U.S. is now in a position of influence and should remain so given continued leadership in the peaceful uses of outer space. Should we be able to achieve further successes in the area of earth observation, that lead will continue. With other competitors appearing on the remote sensing horizon, we should pause to reconsider the galvanizing effect Sputnik had on our nation as we became number two for a brief and uncomfortable period. The nation used the Sputnik experience to produce a more viable space program and in doing so rapidly gained leadership in space. With more countries entering competition, recovery from a future setback would not be certain.

In the area of cooperation, our highest priority should be in international efforts focused on the environment and the impact of global change. This is important for two reasons; 1) a growing recognition that a healthy global environment is important for all nations and 2) the United States in such cooperative actions will be in a position to maintain its leadership role in earth observation activities and can shape the future of such technologies.

The environment of any nation is part of its resources. In the case of the United States, a healthy environment is needed to allow it to continue its productivity from both an industrial and an agricultural perspective. The same is true for many other nations. The economies of the world depend upon industrial production to fuel growth and improve standards of living and, at the same time, must feed a growing population. Continued deterioration of the environment has the potential to stagnate economic growth and increase hunger. Either condition can result conditions that could threaten the survival of a nation.

The second reason for cooperation in environmental efforts is the maintenance of U.S. leadership in space. In terms of operating space systems, technology, and a supporting industrial infrastructure for space activities, the U.S. is in the lead. Should the U.S. pursue taking the lead in such projects as Mission to Planet Earth, other nations will be influenced by U.S. actions and technology. In this way, the U.S. can expect to influence the future of earth observation from space.

Involvement in international endeavors of the size and complexity required to assess and study global change requires an organization to facilitate cooperation and to apply international resources. The success of

missions to study Halley's Comet suggest that an organization such as the Inter-Agency Consultative Group is a good model for future international coordinating agencies. The United States, if it is to get the most from the benefits of shared costs and risks, should actively seek participation and leadership in such organizations. With the increasing costs and complexity of remote sensing activities, international cooperation will grow in importance.

The United States has a strong desire to be successful in its pursuit of excellence and leadership in space related activities. This is apparent in its policies and in its accomplishments. Earth observation from space can make its own unique contributions and therefore contribute to the power and prestige of the nation by being a fierce competitor in selected areas and a contributor as well as benefactor in selected cooperative international efforts.

ENDNOTES

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2. The terms "earth observation", "earth observation from space" and "remote sensing" will be used interchangeably.

3. The definition is a construct based on the current use of remote sensing equipment and includes the principal elements of the United Nations definition of remote sensing contained in Resolution 41/65, "Principles relating to remote sensing of the Earth from space", dated 3 Dec. 1986.

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